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PARASITOIDS (HYMENOPTERA: BRACONIDAE: APHIDIINAE) OF APHIDS ON BIG SAGEBRUSH (*ARTEMISIA TRIDENTATA* NUTTALL) AND PRAIRIE SAGE (*ARTEMISIA LUDOVICIANA* NUTTALL) IN WASHINGTON STATE

K. S. PIKE, P. STARÝ, D. ALLISON, G. GRAF, L. BOYDSTON, AND T. MILLER

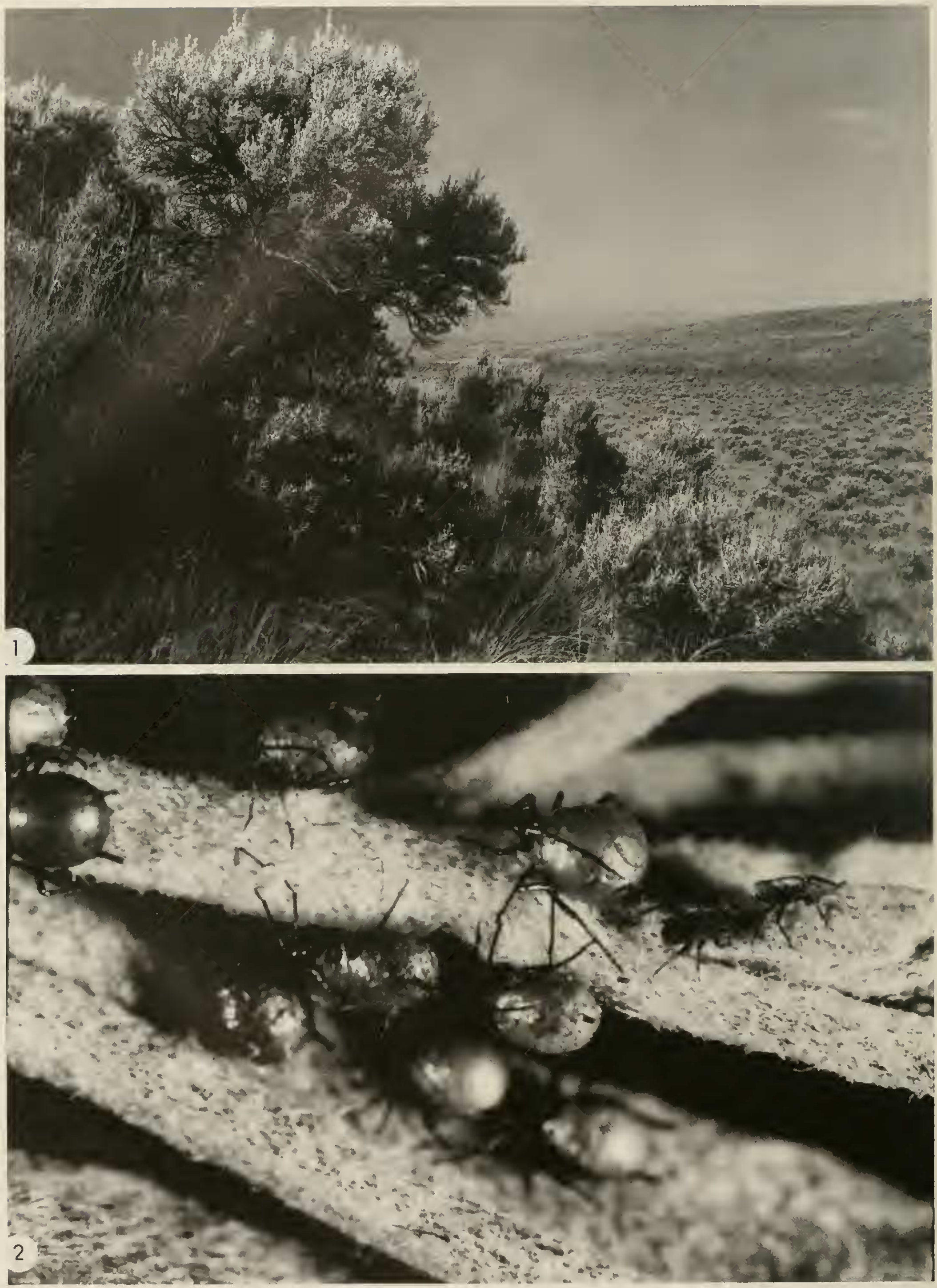
(KSP) Entomologist and (DA, GG, LB) Research Technologists, Washington State University, Irrigated Agriculture Research and Extension Center, 24106 N Bunn Road, Prosser, WA, 99350 U.S.A.; (PS) Entomologist, Institute of Entomology, Academy of Sciences of the Czech Republic, Branišovská 31, 370 05 České Budějovice, Czech Republic; (TM) Insectary Manager, Northwest Biocontrol Insectary and Quarantine, Washington State University, Pullman, WA 99164-6382, U.S.A.

Abstract.—Parasitoid-aphid associations on big sagebrush, *Artemisia tridentata* Nuttall and prairie sage, *Artemisia ludoviciana* Nuttall in Washington State are determined, and the parasitoid species are reviewed and keyed. Two new species of aphidiine parasitoids are described and illustrated: **Praon artemisicola Pike and Starý**, n. sp. (hosts: *Epameibaphis atricornis* Gillette & Palmer, *Flabellomicrosiphum* sp. and *Pseudoepameibaphis tridentatae* Wilson; also from mixed populations of *Flabellomicrosiphum knowltoni* Smith, *Obtusicauda filifoliae* Gillette and Palmer, and *Pleotrichophorus* sp. on *A. tridentata*), and **Trioxys artemisiarum Pike and Starý,** n. sp. (host: *Macrosiphoniella ludovicianae* (Oestlund) on *A. ludoviciana*). The sagebrush areas of the region are relatively widespread with mainly indigenous flora; the associated aphids and parasitoids are also indigenous and constitute a relatively rich diversity of species. Twelve species of sagebrush and prairie sage aphid-parasitoids are known from the region.

Key Words: sagebrush, *Artemisia*, aphids, parasitoids, *Praon artemisicola* n. sp., *Trioxys artemisiarum* n. sp., biodiversity

Big sagebrush (*Artemisia tridentata* Nuttall) (Fig. 1) occurs across vast reaches and fragmented tracts of land within the interior areas of the Pacific Northwest where precipitation is commonly less than 50 cm per year. Big sagebrush is indigenous to the region and somewhat competitive with perennial grasses (Whitson et al. 1991) and other plants. The sagebrush communities commonly adjoin agricultural lands, sometimes dryland grain fields, sometimes irrigated fields. Prairie sage (*Artemisia ludoviciana* Nuttall) is also common in the region, but restricted more to streambanks and flood plains.

A recent review of Pacific Northwest aphidiine parasitoids by the authors (Pike et al. 1996) indicated a number of plant communities in which more detailed research should be undertaken, including sagebrush. Further, a catalog by Marsh (1979) of North American aphidiines showed little information for the Northwest. We theorized that sagebrush or sagebrush and other plants in the sagebrush ecosystem, especially in undisturbed settings, might harbor parasitoids (Fig. 2) useful against aphids in adjoining crops or serve as a stable source for such. Distinguishing tritrophic associations (parasitoid-aphid-plant) in ecosystems or agro-



Figs. 1–2. 1, Big sagebrush landscape, WA, Benton Co., Rattlesnake Hills, 1-VI-96 (photo by L. C. Wright, Res. Tech. Supervisor, Washington State University, Prosser, WA). 2, *Obtusicauda coweni* aphids on big sagebrush parasitized by *Lysiphlebus utahensis*, WA, Yakima Co., near Wenas Lake, 30-V-96 (photo by K. S. Pike).

ecosystems constitute one of the first steps needed in biodiversity research, and for advancing the use of or enhancing aphid biological controls. The purpose of this research was to define the diversity of aphidiine parasitoids and their associated aphid-hosts on big sagebrush and prairie sage, describe new species as appropriate, and present a key to the parasitoids of big sagebrush and prairie sage aphids.

MATERIALS AND METHODS

Big sagebrush and prairie sage were extensively sampled for aphids and aphid-parasitoids across eastern Washington, covering Asotin, Benton, Douglas, Franklin, Klickitat, Kittitas, and Yakima counties. A total of 130 samples was taken over three years (1994–96), and 831 parasitoids were reared and examined. The collected live aphids from which parasitoids were reared, were held in semi-transparent plastic containers (300 ml, 10 cm dia × 4 cm ht or 3500 ml, 18 cm dia × 13 cm ht) on clipped foliage at laboratory temperatures of 20 ± 3°C for 25–30 days to provide time for parasitoids to develop; adults generally emerged within 10 days.

New descriptions were based on whole dry and dissected slide-mounted specimens evaluated under microscope at 40 to 600×. Measurements were recorded in millimeters. Holotypes were dry-mounted on paper tabs and pinned. Descriptive terminology is after Huber and Sharkey (1993). Holotypes are deposited in the National Museum of Natural History, Smithsonian Institution, Washington DC (USNM).

REVIEW OF PARASITOID SPECIES OF BIG SAGEBRUSH (BS) AND PRAIRIE SAGE (PS) APHIDS

Parasitoid species are listed alphabetically. References, if any, are listed at the end of each record of aphid host, location, and date of collection. All aphids were collected and identified by the authors, unless otherwise indicated. Numbers in parentheses represent authors' codes of voucher specimens (aphid-parasitoids) in Washington State University (WSU)-Prosser collections.

Aphidius polygonaphis Fitch, all from aphids on PS: USA, WA, Yakima Co., Yakama Indian Res., Yakima Chief Rd., 16-V-96, from *Macrosiphoniella ludovicianae* and *Pleotrichophorus* sp. (96G053), Mabton Rd., 25-IV-96 (96K004), and Lower Mill Cr. Rd., 25-V-96, (96K054) from *Macrosiphoniella ludovicianae.*

Binodoxys coruscanigrans (Gahan): USA, WA, Yakima Co., Mabton Grade, 23-V-96, and near Wenas Lake, 30-V-96, from *Obtusicauda coweni* on BS (96G068, 96G115).

Binodoxys clydesmithi Pike & Starý, all from aphids on BS: USA, WA, Franklin Co., Kahlotus Hwy, Neff Farm, 28-V-96, from *Obtusicauda artemisicola* (96G096); Kittitas Co., Lost Lake, 7-VII-94, from *Obtusicauda coweni* and *Zyxaphis* sp. (det. G. Remaudière) (94K042) (Pike et al. 1996).

Ephedrus californicus Baker, all from aphids on BS unless indicated otherwise: USA, WA, Klickitat Co., Roosevelt, 9 & 24-IV-96, from *Obtusicauda* sp. (96G011, 96G015), 16-IV-96, from *Obtusicauda artemisiphila* (96G012); Yakima Co., Mabton Grade, 14-V-96, from *Obtusicauda coweni* (96G026); Yakama Indian Res., Mabton Rd., 25-IV-96, from *Macrosiphoniella* nr. *ludovicianae* on PS (96K004), 16-V-96, from *Macrosiphoniella ludovicianae* and *Pleotrichophorus pseudoglandulosus* on PS (96G049).

Lysaphidus adelocarinus (Smith), all from aphids on BS: USA, WA, Benton Co., Arid Lands Ecol. Reserve, Rattlesnake Springs, 10-V-96, from *Epameibaphis atricornis*, *Microsiphoniella* sp., *Obtusicauda* sp. and *Pleotrichophorus* spp. (95G032), Snively Springs, 19-V-95, from *Epameibaphis atricornis* and *Pseudoepameibaphis tridentatae* (95G072), near Rothrock and Pearl Rds., 29-VI-95, from *Flabellomicrosiphum knowltoni*, *Pseudoepameibaphis tridentatae* and *Zyxaphis canae* (95G280); Franklin Co., Juniper Dunes Wilderness, 23-V-95, from *Flabellomicrosiphum knowltoni* and *Microsiphoniella acophorum* (95G088, 95G089), Kahlotus Hwy, Neff Farm, 28-V-96, from *Obtusicauda artemisicola* (96G096); Kittitas Co., Ellensburg, 20-VI-95, from *Pseudoepameibaphis tridentatae* (95G198), Taneum Rd., 11-IX-95, from *Pleotrichophorus* sp., *Pseudoepameibaphis glauca*, and *Zyxaphis* sp. (95G586); Klickitat Co., Alderdale Cr. & Columbia River, 28-IV-95, from *Pleotrichophorus* sp. (95G012), 2-IV-96, from *Flabellomicrosiphum tridentatae*, *Obtusicauda* sp. and *Pseudoepameibaphis tridentatae* (96G007), near Alderdale, 9-V-95, from *Pleotrichophorus* sp. (95G026), *Flabellomicrosiphum* sp., *Obtusicauda filifoliae* and *Pseudoepameibaphis tridentatae* (95G027), 11-VII-95, from *Flabellomicrosiphum tridentatae* and *Pseudoepameibaphis essigi* (95G345), Roosevelt, 24-IV-96, from *Obtusicauda* sp. (96G015); Yakima Co., Moxee Hwy 24, 15-V-95, from *Epameibaphis atricornis* and *Flabellomicrosiphum knowltoni* (95G066), Plank Rd., 15-V-95, from *Pseudoepameibaphis tridentatae* (95G069), Fort Simcoe, 30-V-95, from *Flabellomicrosiphum knowltoni* and *Pseudoepameibaphis tridentatae* (95G091), Yakama Indian Res., near White Swan, 6-VI-95, from *Obtusicauda filifoliae* and *Pseudoepameibaphis tridentatae* (95G110), Yakama Indian Res. near Satus, 16-V-96, from *Epameibaphis atricornis*, *Flabellomicrosiphum* sp., and *Pseudoepameibaphis tridentatae* (96G062), Yakama Indian Res., Mabton Rd., 25-IV-96, from *Obtusicauda* sp. (96K005), Yakima Firing Range, 24-VII-95, from *Obtusicauda* sp., and *Pseudoepameibaphis tridentatae* (95G370).

Lysaphidus ramithyrus (Smith): USA, WA, Kittitas Co., Taneum Rd, 11-IX-95, from *Pleotrichophorus* sp. and *Zyxaphis* sp. on BS (95G585).

Lysiphlebus utahensis (Smith), all from aphids on BS: USA, WA, Franklin Co., Kahlotus Hwy, Neff Farm, 28-V-96, from *Obtusicauda artemisicola* (96G096); Klickitat Co., near Roosevelt, 2 & 9-IV-96, from *Obtusicauda filifoliae* (96G009) and *Obtusicauda* sp. (96G011); Yakima Co., Mabton Grade, 23-V-96, and near Wenas Lake, 30-V-96, from *Obtusicauda coweni* (96G068, 96G115, 96G122).

Praon artemisaphis Smith, all from aphids on BS: USA, WA, Klickitat Co., Roosevelt, 9-IV-96, from *Obtusicauda* sp. (96G011); Yakima Co., Mabton Grade, 14 & 23-V-96, and near Wenas Lake, 30-V-96, from *Obtusicauda coweni* (96G026, 96G068, 96G115), Yakama Indian Res., Mabton Rd., 25-IV-96, from *Flabellomicrosiphum knowltoni* and *Pleotrichophorus* sp. (96K003), from *Obtusicauda* sp. (96K005).

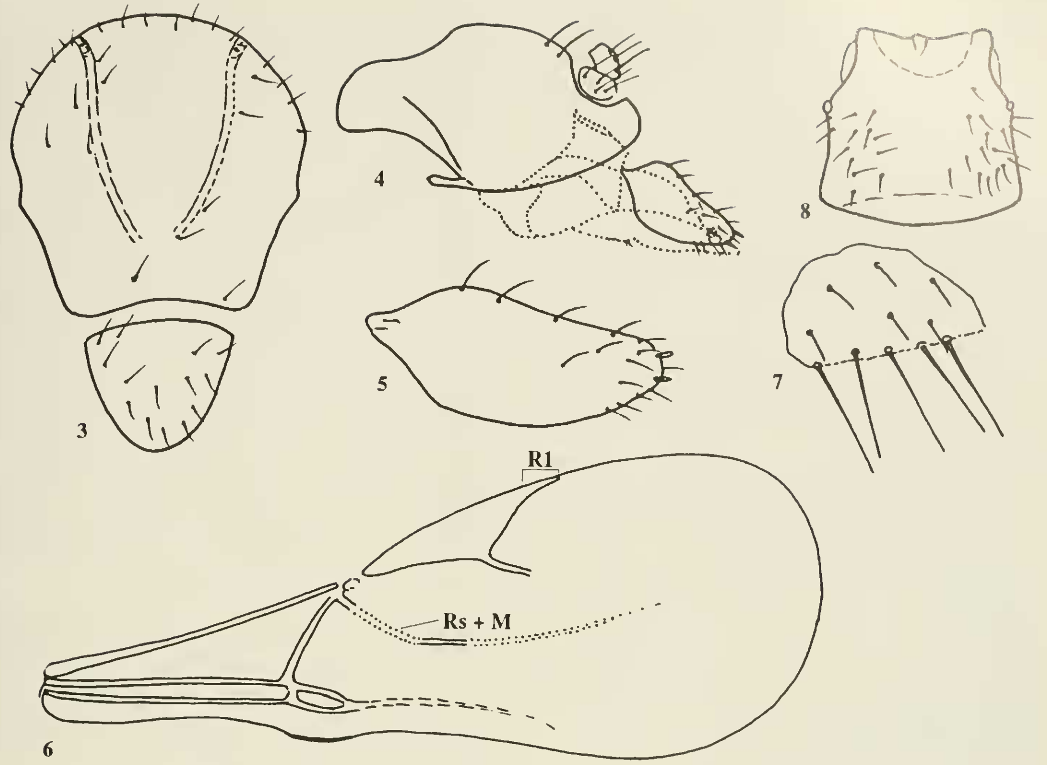
Praon artemisicola Pike & Starý, new species

(Figs. 3–8)

Diagnosis.—Following the key by Johnson (1987), the new species has several characters (radial sector length, distal abscissa of R1 length, and stigma width) in common with *P. artemisaphis* Smith, but differs in the number of antennal segments (13–14) and status of the m-cu vein (almost to completely effaced).

Etymology.—The new species name is derived from its association with big sagebrush, *Artemisia tridentata*.

Description.—*Female:* Head. Malar space equal to ⅙ of eye length. Face glabrous, with a row of setae along orbits. Antenna 13–14 segmented, short, filiform, as long as head, mesosoma and basal third of metasoma together. Flagellomere 1 (= F_1) 4× as long as wide, with sparse long oblique setae slightly longer than half segment diameter, no longitudinal placodes. F_2 3× as long as wide, with one placode. Middle flagellomeres 2.5× as long as wide, with sparse oblique setae subequal to seg-



Figs. 3–8. *Praon artemisicola* (illustrations not to equal scale). 3, Mesonotum. 4, Genitalia. 5, Ovipositor sheath. 6, Forewing. 7, Forewing lower margin close-up. 8, Metasomal tergum 1. Abbreviations: R1, radial abscissa (= metacarpus); Rs + M, wing vein.

ment diameter. Preapical flagellomere as wide as middle flagellomeres.

Mesosoma. Mesonotum (Fig. 3) with all lobes glabrous, with a few scattered setae along the notauli. Propodeum smooth.

Forewing (Figs. 6–7). Stigma 4× as long as wide; distal abscissa of R1 (= metacarpus) relatively short, equal to ⅐ of stigma length. Radial sector equal to stigma width; median vein discolored in the proximal portion; m-cu vein effaced except sometimes for a short discolored proximal stub. Lower marginal setae (Fig. 7) 5× as long as surface setae.

Legs. Hind femur with sparse semi-erect setae that are slightly longer than half segment diameter.

Metasoma. Metasomal tergum 1 (Fig. 8) square, with groups of setae close to hind corners.

Genitalia (Figs. 4–5).

Coloration. Head dark brown, mandibles brown, palpi light brown. Antenna brown, pedicel and basal ⅔ of F_1 yellow to light brown with lighter basal ring. Mesosoma dark brown. Wings subhyaline, venation light brown. Fore leg yellow brown to brown, middle and hind legs brown, base of tibiae lighter. Metasoma brown, tergum 1 light brown. Ovipositor sheath brown.

Body length about 1.6–1.8 mm.

Male: Antenna 16–17 segmented, long, subequal to body length. Concolorous, somewhat darker than female. Antenna dark brown, narrow apex of pedicel and a narrow basal ring of F_1 light brown. Metasoma brown, tergum 1 dark brown.

Holotype [♀].—USA, WA, Yakima Co., Alderdale and Glade Rd., 9-V-95, reared from (mixed aphids) *Epameibaphis atricor-*

nis Gillette & Palmer, *Flabellomicrosiphum* sp., and *Pseudoepameibaphis tridentatae* (Wilson) taken from big sagebrush, *Artemisia tridentata* Nuttall, coll. G. Graf, sample no. 95G030. Deposited in USNM.

Paratypes.—reared from aphids on big sagebrush, *Artemisia tridentata*: USA, WA, Benton Co., Crosby Rd. 1-V-95, from *Pseudoepameibaphis tridentatae* (95G015, 3 ♂), Hwy 240 and Horn Rapids, 12-V-95, from *Pseudoepameibaphis tridentatae* (95G041, 1 ♀); Klickitat Co., Alderdale Rd., 9-V-95, from *Flabellomicrosiphum* sp., *Pseudoepameibaphis tridentatae*, and *Obtusicauda filifoliae* (95G027, 1 ♀), near Alderdale, 9-V-95, from *Pleotrichophorus* sp. and *Pseudoepameibaphis tridentatae* (95G028, 1 ♀), Alderdale Rd., 5mi N of Hwy 14, 12-V-95, from *Epameibaphis atricornis* (95G037, 1 ♀); Yakima Co., Alderdale and Glade Rd., 9-V-95, from *Epameibaphis atricornis*, *Flabellomicrosiphum* sp. and *Pseudoepameibaphis tridentatae* (95G030, 2 ♀), Moxee Hwy, 15-V-95, from *Epameibaphis atricornis*, *Flabellomicrosiphum knowltoni* (95G066, 1 ♀, 2 ♂), Plank Rd., 15-V-95, from *Pseudoepameibaphis tridentatae* (95G069, 2 ♂). Material deposited in part in the Washington State University Collection, James Museum, Pullman, WA; the Washington State University-Prosser Collection, and the collection of P. Starý, Česke Budějovice, Czech Republic.

Praon occidentale Baker: USA, WA, Yakima Co., Yakama Indian Res., Mabton Rd., 25-IV-96, from *Macrosiphoniella ludovicianae* on PS (96K004).

Trioxys artemisiarum Pike & Starý, new species

(Figs. 9–12)

Diagnosis.—Following the key by Smith (1944), the new species has characters in common with *T. bonnevillensis* Smith and *T. infrequens* Smith. *T. bonnevillensis* differs from the new species in having somewhat shorter prongs, four perpendicular setae dorsally, and with oblique setae distinctly longer than prong diameter. *T. infrequens* (based on Smith's 1944 original description) differs from the new species in having prongs fused along basal halves, and flagellomeres approximately equal in length and unusually long. Also, the antenna of the new species is 12-segmented vs. 11-segment in *T. bonnevillensis* and *T. infrequens*.

Etymology.—The new species name is derived from its association with *Artemisia*.

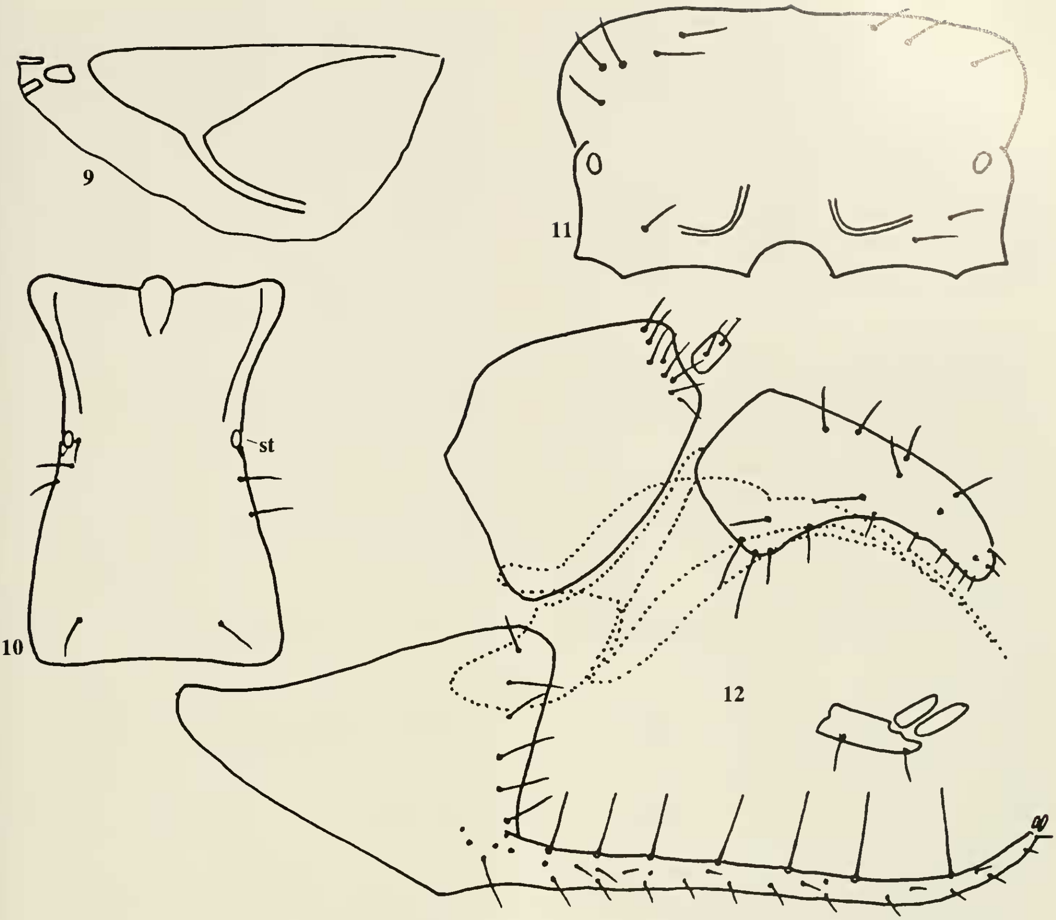
Description. *Female:* Head. Eyes prominent, strongly convergent to clypeus. Malar space equal to ⅙ of eye length. Tentorioculear line equal to ¼ of intertentorial line. Antenna 12-segmented, filiform, reaching to middle of metasoma; middle to apical flagellomeres equal in width, gradually shorter towards apex of flagellum. Second flagellomere (F_2) 3× as long as wide, middle flagellomeres 2.3× as long as wide.

Mesosoma. Mesonotum with simple rows of relatively sparse setae along effaced notauli of disc. Propodeum (Fig. 11) smooth, with two short divergent carinae in distal portion.

Forewing (Fig. 9) stigma triangular, almost 3× greatest width; distal abscissa of R1 (= metacarpus) relatively short, shorter than ⅓ stigma length or distinctly shorter than stigma width. Radial sector short, somewhat longer than stigma width. Hind femur and tibia with adpressed setae.

Metasoma. Metasomal tergum 1 (Fig. 10) somewhat longer than 2× spiracular width, dilating from poorly prominent spiracular tubercles to apex, about 1.5× as wide at apex as across spiracles.

Genitalia (Fig. 12). Ovipositor sheath distinctly claw-shaped. Prongs long and straight except for upward curve at apex, distinctly separated along their length, 7–8 long perpendicular setae on dorsal surface (setae gradually increasing in length towards apex of prong, length 2–3× adjacent prong diameter), numerous shorter oblique setae on ventral surface (length subequal to adjacent prong diameter), sternal base of prongs with a single row of long, longitudinal setae (subequal in length to dorsal se-



Figs. 9–12. *Trioxys artemisiarum* (illustrations not to equal scale). 9, Forewing, in part. 10, Metasomal tergum 1. 11, Propodeum. 12, Genitalia. Abbreviation: st, spiracular tubercle.

tae), and prong apex with two longitudinally dilated setae.

Coloration. Distinctly bicolorous, with some variation. Head yellow; ocellar triangle brown, sometimes brown from frons to vertex. Antenna dark brown, most of scape and pedicel, and whole of F_1 yellow. Mesosoma brown black, sometimes prothorax yellow brown. Tegulae yellow. Wings subhyaline, venation brown. Legs brown, tinge darkest in hind leg; trochanter, base and narrow apex of tibia and tarsomere 1 or most of tarsus yellow. Metasoma distinctly bicolorous, middle part prevalently dark brown; tergum 1 and central spot at tergum 2 light brown. Middle terga sometimes with light lateral spots; apex yellow. Last tergum with central brown spot, apical half of ovipositor sheath brown; sternum and prongs yellow.

Body length 2.3–2.5 mm.

Male: Antenna 14-segmented. Coloration generally dark brown; apex of pedicel and mandibles yellow. Metasomal tergum 1 and base of tergum 2 light brown.

Holotype [♀].—USA, WA, Asotin Co., Heller's Bar, 20-VI-95, reared from *Macrosiphoniella ludovicianae* (Oestlund) taken from big sagebrush, *Artemisia tridentata* Nutall, coll. T. Miller, sample no. 95T146. Deposited in USNM.

Paratypes.—USA, WA, Asotin Co.,

Couse Creek and Heller's Bar, 20-VI-95, from *Macrosiphoniella ludovicianae* on BS (95T126, 2 ♀, 2 ♂; 95T146, 2 ♂), and 18-VII-95 on PS (95T257, 2 ♀, 3 ♂). Deposited in part in the Washington State University Collection, James Museum, Pullman, WA; the Washington State University-Prosser Collection, and the collection of P. Starý, Česke Budějovice, Czech Republic.

Trioxys bonnevillensis Smith, all from aphids on BS unless indicated otherwise: USA, WA, Benton Co., Arid Lands Ecol. Reserve, Rattlesnake Springs, 10 -V-95, from *Epameibaphis atricornis*, *Microsiphoniella* sp., *Obtusicauda* sp., and *Pleotrichophorus* spp. (95G032), 19-V-95, from *Epameibaphis atricornis* and *Pseudoepameibaphis tridentatae* (95G072), 8-VI-95, *Epameibaphis* sp. and *Pseudoepameibaphis tridentatae* (95G151), Bennett Springs, 2-V-95, from *Epameibaphis atricornis*, *Pleotrichophorus* sp., and *Pseudoepameibaphis tridentatae* (95G018), Hwy 14, 12-V-95, from *Pseudoepameibaphis tridentatae* (95G039), Prosser, 8-VI-95, from *Pseudoepameibaphis tridentatae* (95K032), Rotha Rd, 2-V-95, from *Obtusicauda artemisiae* (95G017), Rothrock Rd., 29-VI-95, from *Flabellomicrosiphum knowltoni*, *Pseudoepameibaphis tridentatae*, and *Zyxaphis canae* (95G280); Douglas Co., Badger Mtn., 13-VII-95, from *Zyxaphis canae* Williams, coll. R. L. Gillespie (95B012); Franklin Co., Juniper Dunes Wilderness, 23-V-95, from *Flabellomicrosiphum tridentatae* and *Microsiphoniella acophorum* (95G088, 95G089); Kittitas Co., Ellensburg, 20-VI-95, from *Pseudoepameibaphis tridentatae* (95G198), Klickitat Co., Alderdale, 11-VII-95, from *Flabellomicrosiphum tridentatae* and *Pseudoepameibaphis essigi* (95G345), Alderdale Cr., 28-IV-95, from *Flabellomicrosiphum tridentatae* (95G013), from *Epameibaphis utahensis*, *Obtusicauda filifoliae* and *Pseudoepameibaphis tridentatae* (95G014), 9-V-95, from *Flabellomicrosiphum* sp., *Obtusicauda filifoliae* and *Pseudoepameibaphis tridentatae* (95G027), 12-V-95, from *Pseudoepameibaphis tridentatae* (95G038), Roosevelt, 2-IV-96, from *Obtusicauda filifoliae* (96G009), 9-IV-96, *Obtusicauda* sp. (96G011), 16-IV-96, from *Obtusicauda artemisiphila* (96G012); Yakima Co., Hwy 82, 12-V-95, from *Epameibaphis atricornis* and *Pseudoepameibaphis tridentatae* (95G043), 12-V-95, from *Pseudoepameibaphis tridentatae* (95G044), Moxee Hwy, 15-V-95, from *Epameibaphis atricornis* and *Flabellomicrosiphum knowltoni* (95G066), Hwy 82, 15-V-95, from *Epameibaphis atricornis* and *Pseudoepameibaphis tridentatae* (95G067), Fort Simcoe, 30-V-95, from *Flabellomicrosiphum knowltoni* and *Pseudoepameibaphis tridentatae* (95G091), White Swan, 6-6-95, from *Obtusicauda filifoliae* and *Pseudoepameibaphis tridentatae* (95G110), Yakima Firing Range, 24-VII-95, from *Obtusicauda* sp. and *Pseudoepameibaphis tridentatae* (95G370), Yakama Indian Res., Chief Rd, 25-IV-96, from *Obtusicauda* sp. (96K005), from *Obtusicauda* sp. and *Pseudoepameibaphis tridentatae* on PS (96G020), Yakama Indian Res. near Satus, 16-V-96, from *Epameibaphis atricornis*, *Pseudoepameibaphis tridentatae* and *Flabellomicrosiphum* sp. (96G062).

KEY TO PARASITOID SPECIES (FEMALES) REARED FROM APHIDS ON *ARTEMISIA* SPP. IN EASTERN WASHINGTON STATE

1. Forewing Rs + M vein present, sometimes more or less colorless, but distinct in fore part (Figs. 6, 14, 22, 23) 2
– Forewing Rs + M vein absent (Figs. 13, 25) 5
2(1). Forewing 1R1 and 1 + 2Rs cells separate; r-m vein present (Fig. 14) . . . . *Ephedrus californicus* Baker
– Forewing 1R1 and 1 + Rs confluent; r-m vein absent (*Praon*) (Figs. 6, 22, 23) 3
3(2). Forewing m-cu vein present (Figs. 22, 23); antenna 16–18 segmented 4
– Forewing m-cu vein absent (Fig. 6); anten-

na 13–14 segmented . . . . *Praon artemisicola* Pike & Starý, n. sp.

4(3). Forewing distal abscissa of R1 (= metacarpus) and radial sector short, equal to width of stigma (Fig. 22); antenna 16–17 segmented . . . . . . *Praon artemisaphis* Smith

– Forewing distal abscissa of R1 and radial sector long, at least 1.5–2.0 times longer than width of stigma (Fig. 23); antenna 17–18 segmented . . . . . *Praon occidentale* Baker

5(1). Forewing r-m vein present (Figs. 13, 24, 25); last abdominal sternite simple, without prongs; ovipositor sheath slightly curved upwards (Figs. 16, 17, 29) 6

– Forewing r-m vein absent (Figs. 27, 28); last abdominal sternite with fork-like accessory prong; ovipositor sheath curved downward (Figs. 12, 30, 32, 34) 9

6(5). Forewing M + m-cu vein complete (Fig. 13) . . . . *Aphidius polygonaphis* Fitch

– Forewing M + m-cu vein incomplete (Fig. 25) 7

7(6). Propodeum with more or less distinct areola or at least carinae (Figs. 19–20); metasomal tergum 1 somewhat parallel-sided (Fig. 21) (*Lysaphidus*) 8

– Propodeum smooth (Fig. 18); metasomal tergum 1 somewhat triangular, distinctly enlarged at apex (Fig. 15) . . . . *Lysiphlebus utahensis* (Smith)

8(7). Propodeum with two divergent carinae in distal portion (length of carinae variable) (Fig. 20) . . *Lysaphidus adelocarinus* (Smith)

– Propodeum areolated, with small central pentagonal areola (size and shape variable) (Fig. 19) . . . . *Lysaphidus ramithyrus* (Smith)

9(5). Metasomal tergum 1 with spiracular and secondary tubercles (Fig. 26) 10

– Metasomal tergum 1 with spiracular tubercles only (Figs. 10, 31) 11

10(9). Lower apical part of metasoma yellow, prongs dark; spiracular and secondary tubercles of metasomal tergum 1 of equal size, distinctly separated from each other; prongs feeble, with 4–5 long setae on dorsal surface in basal portion (Fig. 33); ovipositor sheath broad in basal two-thirds, almost claw-shaped (Fig. 32) . . . . *Binodoxys coruscanigrans* (Gahan)

– Lower apical part of metasoma brown, concolorus with remaining metasoma, prongs dark brown; spiracular and secondary tubercles of metasomal tergum 1 closely spaced, secondary tubercles slightly greater than spiracular tubercles (Fig. 26); ovipositor sheath not claw-shaped, comparatively narrow at base (Fig. 30); prongs strong, with 7 long setae on dorsal surface (Fig. 30); stigma length 3x width (Fig. 28) . . . . *Binodoxys clydesmithi* Pike & Starý

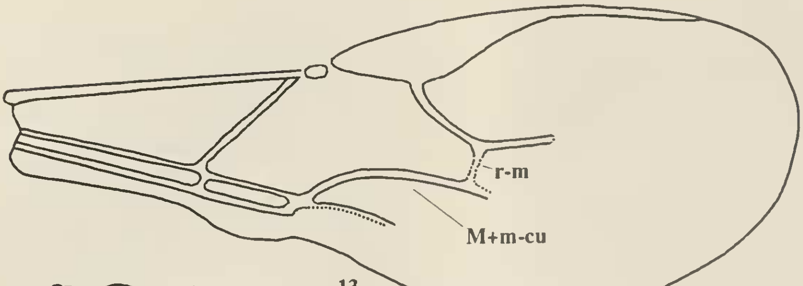
11(9). Prongs of last metasomal sternum short, arcuate, each bearing 4 long perpendicular setae on dorsal surface (Fig. 34); radial sector shorter than stigma width (Fig. 27) . . . . *Trioxys bonnevillensis* Smith

– Prongs of last metasomal sternum long, straight, with apices curved upward, each bearing 7–8 perpendicular setae on dorsal surface (Fig. 12); radial sector longer than stigma width (Fig. 9) . . . . *Trioxys artemisiarum* Pike & Starý, n. sp.

Aphid-Parasitoid-Plant Associations Listing

(BS, big sagebrush; PS, prairie sage. *, parasitoid reared from a collection of mixed aphids; specific association shown considered valid by authors)

Epameibaphis atricornis Gillette & Palmer
  *_Lysaphidus adelocarinus_ (BS)
  *_Praon artemisicola_ (BS)
  *_Trioxys bonnevillensis_ (BS)
Epameibaphis utahensis Knowlton & Smith
  *_Trioxys bonnevillensis_ (BS)
Flabellomicrosiphum knowltoni Smith
  *_Lysaphidus adelocarinus_ (BS)
  Praon artemisaphis (BS)
  *_Praon artemisicola_ (BS)
  *_Trioxys bonnevillensis_ (BS)
Flabellomicrosiphum tridentatae (Wilson)
  *_Lysaphidus adelocarinus_ (BS)
  *_Trioxys bonnevillensis_ (BS)
Flabellomicrosiphum sp.
  *_Lysaphidus adelocarinus_ (BS)
  *_Praon artemisicola_ (BS)
  *_Trioxys bonnevillensis_ (BS)
Macrosiphoniella ludovicianae (Oestlund)
  *_Aphidius polygonaphis_ (PS)
  Ephedrus californicus (PS)
  *_Praon occidentale_ (PS)
  *_Trioxys artemisiarum_ (BS)
Microsiphoniella acophorum (Smith & Knowlton)
  *_Lysaphidus adelocarinus_ (BS)



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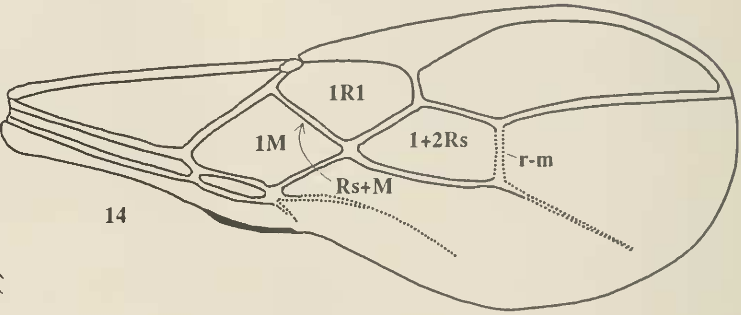

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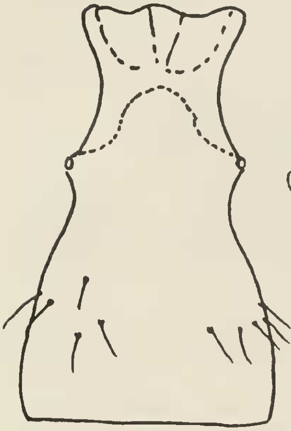

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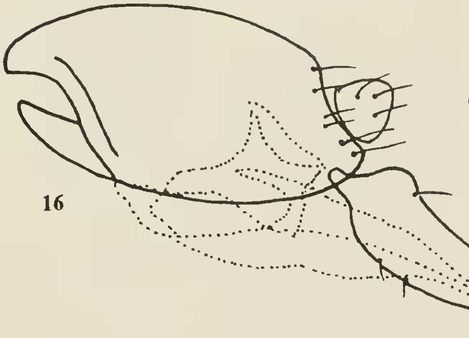

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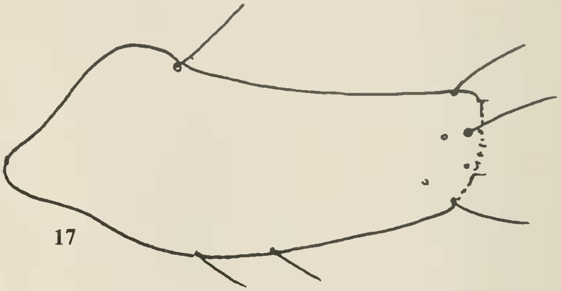


17

Figs. 13–17. Various features of parasitoids of big sagebrush and prairie sage aphids (illustrations not to equal scale). 13, *Aphidius polygonaphis*, forewing. 14, *Ephedrus californicus*, forewing. 15–17, *Lysiphlebus utahensis*. 15, Metasomal tergum 1. 16, Genitalia. 17, Ovipositor sheath. Abbreviations: M + m-cu, Rs + M and r-m are wing veins; 1M, 1R1, 1 + 2Rs are wing cells.

- **Trioxys bonnevillensis* (BS)

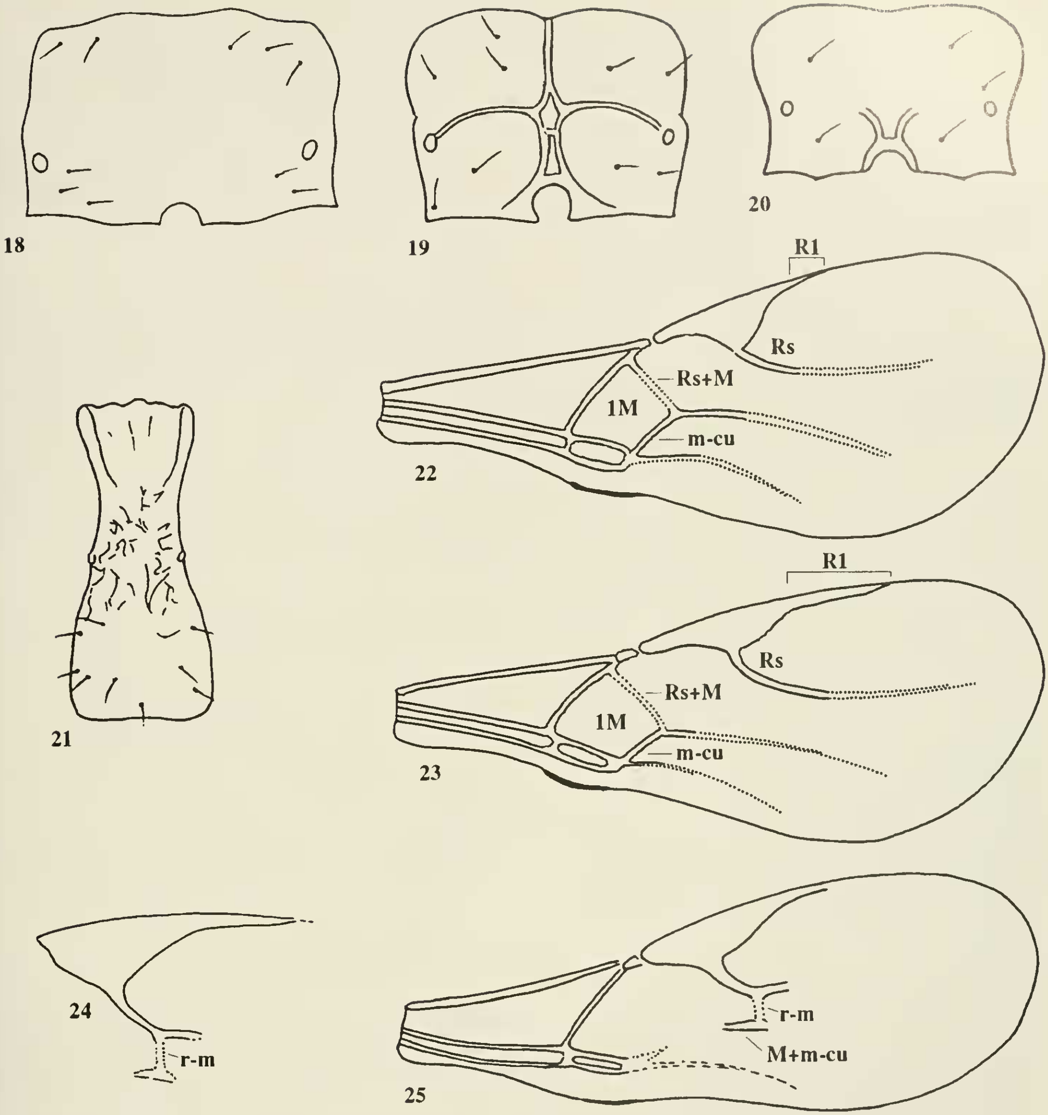
Microsiphoniella sp.
- **Lysaphidus adelocarinus* (BS)
- **Trioxys bonnevillensis* (BS)

Obtusicauda artemisiae (Cowen ex Gillette & Palmer)
- **Trioxys bonnevillensis* (BS)

Obtusicauda artemisicola (Williams)
- **Binodoxys clydesmithi* (BS)
- **Lysiphlebus utahensis* (BS)
- **Lysaphidus adelocarinus* (BS)

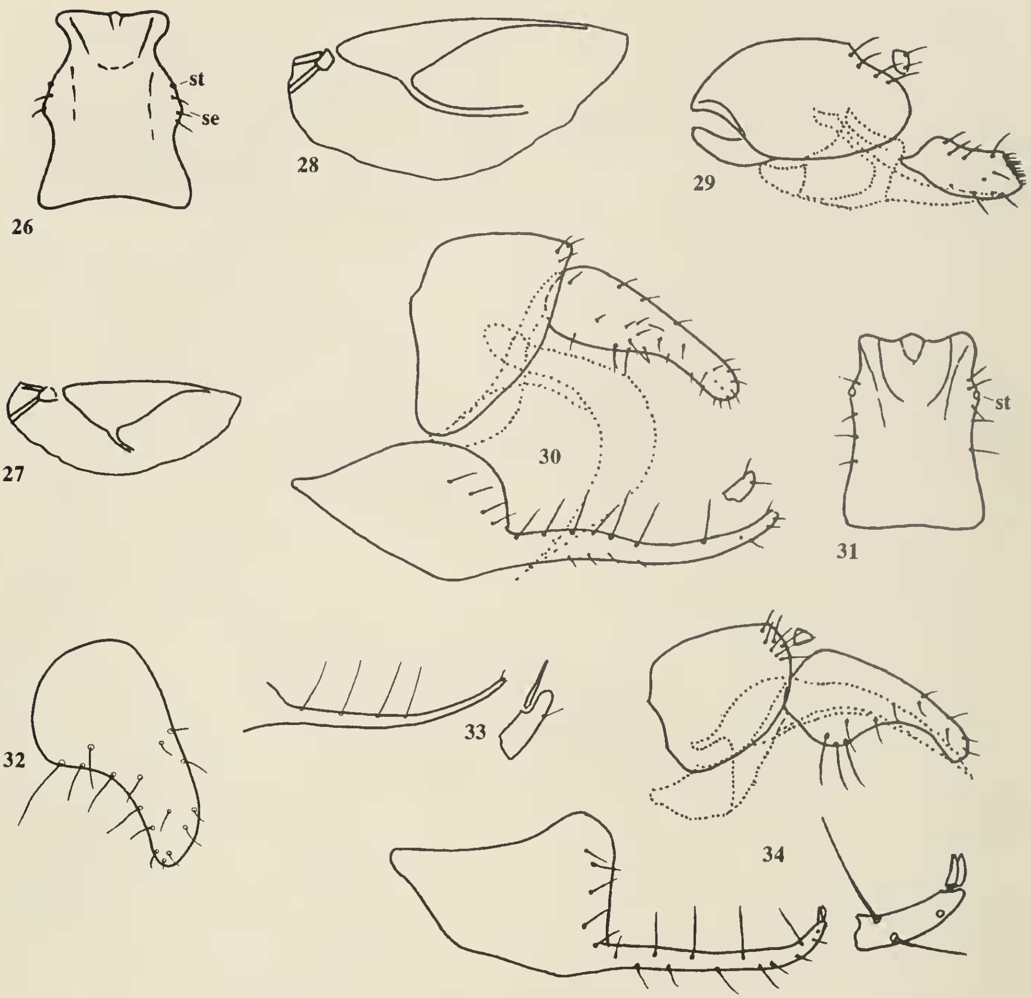
Obtusicauda artemisiphila (Knowlton and Allen)
- **Ephedrus californicus* (PS)
- *Trioxys bonnevillensis* (BS)

Obtusicauda coweni Hunter



Figs. 18–25. Various features of parasitoids of big sagebrush and prairie sage aphids (illustrations not to equal scale). 18, 24, *Lysiphlebus utahensis*. 18, Propodeum. 24, Forewing, in part. 19, 21, *Lysaphidus ramithyrus*. 19, Propodeum. 21, Metasomal tergum 1. 20, 25, *Lysaphidus adelocarinus*. 20, Propodeum. 25, Forewing. 22, *Praon artemisaphis*, forewing. 23, *Praon occidentale*, forewing. Abbreviations: R1 (radial abscissa, = metacarpus), Rs (radial sector), Rs+M, M+m−cu, m-cu, and r−m are wing veins; 1M, wing cell.

  *_Binodoxys clydesmithi_ (BS)
  *_Binodoxys coruscanigrans_ (BS)
  *_Ephedrus californicus_ (BS)
  *_Lysiphlebus utahensis_ (BS)
  *_Praon artemisaphis_ (BS)
Obtusicauda filifoliae (Gillette & Palmer)
  *_Ephedrus californicus_ (PS)
  Lysaphidus adelocarinus (BS)
  *_Lysiphlebus utahensis_ (BS)
  Praon artemisicola (BS)
  Trioxys bonnevillensis (BS)
Obtusicauda sp.
  *_Ephedrus californicus_ (BS)
  Lysaphidus adelocarinus (BS)



Figs. 26–34. Various features of parasitoids of big sagebrush and prairie sage aphids (illustrations not to equal scale). 26, 28, 30, *Binodoxys clydesmithi*. 26, Metasomal tergum 1. 28, Forewing, in part. 30, Genitalia. 27, 31, 34, *Trioxys bonnevillensis*. 27, Forewing, in part. 31, Metasomal tergum 1. 34, Genitalia. 29, *Lysaphidus adelocarinus*, genitalia. 32, 33, *Binodoxys coruscanigrans*. 32, Ovipositor sheath. 33, Prong. Abbreviations: se, secondary tubercle; st, spiracular tubercle.

- **Praon artemisaphis* (BS)
- *Trioxys bonnevillensis* (BS)

Pleotrichophorus pseudoglandulosus (Palmer)
- *Ephedrus californicus* (PS)

Pleotrichophorus sp.
- **Lysaphidus adelocarinus* (BS)
- **Lysaphidus ramithyrus* (BS)
- *Praon artemisaphis* (BS)
- **Praon artemisicola* (BS)
- **Trioxys bonnevillensis* (BS)

Pseudoepameibaphis essigi Knowlton & Smith
- **Lysaphidus adelocarinus* (BS)
- **Trioxys bonnevillensis* (BS)

Pseudoepameibaphis glauca Gillette & Palmer
- **Lysaphidus adelocarinus* (BS)

Pseudoepameibaphis tridentatae (Wilson)
- **Lysaphidus adelocarinus* (BS)
- **Praon artemisicola* (BS)

  ***Trioxys bonnevillensis* (BS)

Zyxaphis canae Williams
  ***Lysaphidus adelocarinus* (BS)
  ***Trioxys bonnevillensis* (BS)

Zyxaphis sp.
  ***Binodoxys clydesmithi* (BS)
  ***Lysaphidus adelocarinus* (BS)
  ***Lysaphidus ramithyrus* (BS)

The aphid-parasitoid fauna on big sagebrush and prairie sage is indigenous and relatively diverse: in total 12 species of parasitoids were found associated with at least 15 species of aphids. A part of these parasitoid species are distributed over other western states and Mexico (Marsh 1979, Starý and Remaudière 1982, 1983, Starý 1983, Johnson 1987). Three of the parasitoid species (*Aphidius polygonaphis*, *Ephedrus californicus*, and *Praon occidentale*) are known to attack selected pestiferous aphids in adjoining crops or forest (Pike et al. 1996). The extent of their value, however, in terms of possible positive connections or movement between sage plant communities (endemic, typically undisturbed ecosystems) and neighboring agroecosystems or introduced landscapes is still largely undetermined.

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LITERATURE CITED

Huber, J. T. and M. J. Sharkey. 1993. Structure, pp. 13–59. *In* Goulet H. and J. T. Huber, eds., Hymenoptera of the World: An Identification Guide to Families. Research Branch, Agriculture Canada, Ottawa, Ontario, Publication 1894/E, 668 pp.

Johnson, J. W. 1987. A revision of the species of *Praon* Haliday in North America north of Mexico (Hymenoptera: Aphidiidae). Canadian Entomologist 119: 999–1025.

Marsh, P. M. 1979. Aphidiidae, pp. 295–313. *In* Krombein, K. V., P. D. Hurd Jr., D. R. Smith, and D. B. Burks, eds., Catalog of Hymenoptera of America North of Mexico. Vol. 1, Symphyta and Apocrita (Parasitica). Smithsonian Institution Press, Washington D.C., 1198 pp.

Pike, K. S., P. Starý, R. Miller, D. Allison, L. Boydston, G. Graf, and T. Miller. 1996. New species and host records of aphid parasitoids (Hymenoptera, Braconidae, Aphidiinae) from the Pacific Northwest, USA. Proceedings of the Entomological Society of Washington 98: 570–591.

Smith, C. F. 1944. The Aphidiinae of North America (Braconidae: Hymenoptera). Ohio State University Contributions in Zoology and Entomology No. 6, 154 pp.

Starý, P. 1983. New species and records of aphid parasitoids from Mexico (Hymenoptera, Aphidiidae). Acta Entomologica Bohemoslovaca 80: 35–48.

Starý, P. and G. Remaudière. 1982. New genera, species and host records of aphid parasites (Hymenoptera: Aphidiidae) from Mexico. Annales de la Societé Entomologique de France, N.S., 18: 107–127.

——— 1983. Complements to the aphid parasitoid fauna of Mexico (Hymenoptera, Aphidiidae). Annales de la Societé Entomologique de France, N.S., 19: 113–116.

Whitson, T. D., L. C. Burrill, S. A. Dewey, D. W. Cudney, B. E. Nelson, R. D. Lee, and R. Parker. 1991. Weeds of the west. Western Society of Weed Science, Western U.S. Land Grant Universities Cooperative Extension Services, and University of Wyoming, Pioneer of Jackson Hole, Jackson, WY, 630 pp.